Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum	)	
Between 3.7 and 24 GHz	)	GN Docket No. 17-183
	)	
	)	
	)	

COMMENTS OF THE NATIONAL SPECTRUM MANAGEMENT ASSOCIATION

David Meyer
Chairman, Working Group 3
NATIONAL SPECTRUM MANAGEMENT ASSOCIATION
P.O. Box 703016
Dallas, TX 75370-3016
703.726.5656

February 15, 2019

TABLE OF CONTENTS

Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum	)	
Between 3.7 and 24 GHz	)	GN Docket No. 17-183
	)	
	)	
	)	

COMMENTS OF THE

NATIONAL SPECTRUM MANAGEMENT ASSOCIATION

The National Spectrum Management Association ("NSMA")[1] submits these comments regarding the above captioned Notice of Proposed Rulemaking (NPRM).

SUMMARY

Issues that are Understood and Considered in the NPRM

Adjacent Channel Protection

Only co-channel (but not adjacent or next to adjacent channel) interference will be considered[2]. This is inconsistent with current industry practice[3] for frequency coordination in this band. Adjacent channel interference must be considered in frequency coordination.

---

[1] The NSMA is a voluntary association of individuals in the spectrum management profession. Our goal is to promote rational spectrum policy through consensus.

[2] Notice of Proposed Rulemaking (NPRM), *Unlicensed Use of the 6 GHz Band*, ER Docket 18-295 (FCC 18-147), page 16, <https://docs.fcc.gov/public/attachments/FCC-18-147A1.pdf>, document referenced as "FCC."

[3] TIA Bulletin 10-F, Annex B, and pending ANSI/TIA Standard 10, Chapter 5

Frequency Coordination to use ULS Database

The FCC Universal Licensing System (ULS) database will be used for all fixed radio service characteristics (FCC page 14). As with many large databases, the ULS is plagued with inaccuracies or lacks critical data. When data is missing or clearly in error, each user will "fill in the blanks" differently. This will undoubtedly cause confusion and misunderstanding among the participants.

Frequency Coordination to Use Propagation Models

The FCC implies propagation models should be used to perform frequency coordination (FCC pages 18 & 19). It should be noted that propagation models estimate typical performance, not actual path performance. Frequency coordination requires an accurate conservative estimate of worst case (lowest loss) propagation. No propagation model has been demonstrated to achieve this.

Issues that are Understood but Not Considered in the NPRM

Automated Frequency Coordination (AFC)

The AFC function(s) should be independent of the operating parties. It should be tasked with resolving interference cases (for fee). Who pays this fee should be determined by the Commission.

AFC databases must be synchronized in an appropriate way. Since missing or defective ULS data will require estimation by the AFC agency, coordination among the users will reduce misunderstandings and inaccurate frequency coordination. Alternatively, an accurate, audited and corrected Universal Licensing System (ULS) 6GHz licensed receiver data could precede unlicensed deployment.

The AFC must record the actual frequency being used by each standard-power access point (FCC page 32). The public should have unfettered (computer readable reports of unlicensed radio parameters without requirement for Non-Disclosure Agreement) access to this data (for a nominal fee is acceptable).

There should be a reasonable limitation to the number of AFC devices that could be operated in a location. The potential victims of interference would prefer a limited number of entities to query for resolution.

Today, frequency coordination is just that - a assessment of potential interference coordinated between the frequency assignment agency and existing licensees. The NPRM proposes automated assignment of frequencies. This does not allow the current licensee to evaluate the frequency assignment. The AFC should at least provide a report for potentially impacted licensees of the new assignment and an abbreviated analysis why it does not represent a problem to the existing licensed user. However, in a congested area, this may be hundreds or thousands of notifications per hour. A periodically updated on-line report available to incumbents might be satisfactory.

Responsibility for Interference Detection and Resolution Undefined

The unlicensed devices will probably have a low duty cycle (in the range of 0.00022% to 0.44% transmission time per RKF study[4], suggesting unlicensed transmissions will be infrequent. This will make an interference source difficult to find in the field even if fixed service links were turned off and specialized equipment were used.

---

[4] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, Table 3-1, page 12, referenced as "RKF", <https://ecfsapi.fcc.gov/file/101261169015803/6%20GHz%20Ex%20Parte%20(Bureaus).pdf>.

A more practical approach to interference identification would be to limit the number of coordinators.

Issues that are Not Currently Understood

Totally Untried Approach

Lastly, the activities proposed by the NPRM are speculative. There are approximately 100,000 6 GHz licensed fixed wireless links in operation today, and that number has steadily grown for decades. These 6 GHz licensed fixed service operations support mission critical communications to hospitals, financial institutions, public safety, utility, railroad, municipal and federal facilities, as well as backhaul to mobile networks, among many other core uses. The proposed unlicensed activities have never been used on scale anywhere in the world and the NPRM proposes to implement its approach without a test. Since we don't know what we don't know, this seems unnecessarily risky. For example, there are no scientific studies that methodically assess what type of interference will be dominant. Direct Interference is the strong interference experienced today in these bands. Frequency coordination has been effective in managing this (although a practical frequency coordination methodology has yet to be defined for the NPRM's proposals). Indirect Interference is the weak background interference (due to obstructed transmitters illuminating nearby buildings and terrain) common in unlicensed bands in large urban areas today. There is no known way to control this.

Testing and economic and public safety considerations are all untested and unknown. A single link of 6 GHz systems typically cost over $1 million. Comprehensive testing followed by an assessment as to real-world feasibility must first occur. If feasibility is scientifically and economically validated, then monitored phase-in of the rules would seem prudent given the potential of low-cost unlicensed systems to disrupt potentially thousands of mission-critical operational networks and their million-dollar licensed paths that depend upon aggressive frequency protection to achieve high necessary system reliability. This untried approach represents a potential danger to national security, public safety, health and welfare which the Fixed Service (FS) links support.

Try Before Fly

Field trials, monitored by all interested parties, should precede large scale implementation. The field trials should be based upon substantial agreement on the testing protocol among all users. Large scale deployment should not begin until the field trials have been successfully completed to the substantial satisfaction of all parties. Comprehensive testing followed by a monitored phase-in of the rules would seem prudent given the potential of low-cost unlicensed systems to disrupt million-dollar licensed paths.

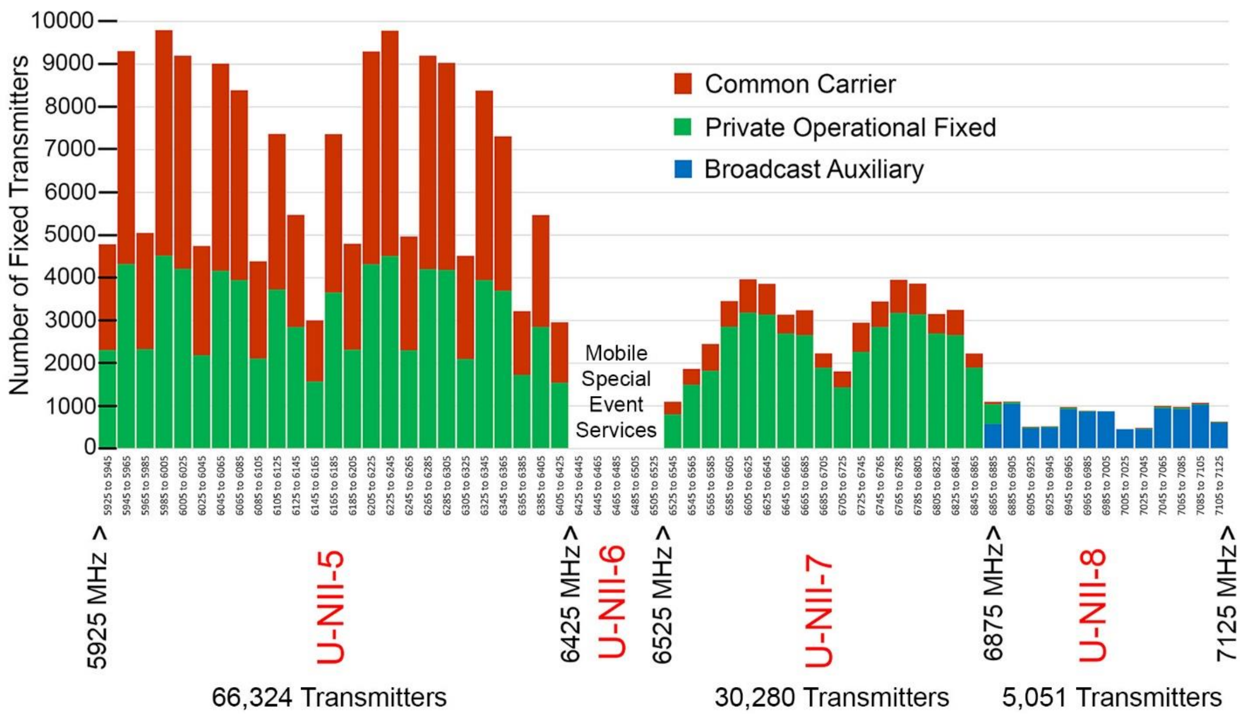
Backup Plan

What is being considered is a totally untried plan. If successful, it could define the first major improvement in spectrum usage efficiency since the International Radiotelegraph Union released the international Table of Frequency Allocations in 1912. If it fails, it could irreparably damage an important radio service using these frequencies since the 1950's. It is strongly recommended that the Commission engage NTIA to allow sharing of their 7 GHz frequencies to allow movement of one or more of the 6 GHz services to that band if the current plan becomes untenable.

INTRODUCTION

In this NPRM the Commission proposes rules that will introduce unlicensed use in portions of the 1200 megahertz of spectrum in the 5.925-7.125 GHz (6 GHz) bands. Relatively high-powered unlicensed devices would be permitted to operate in portions of two sub-bands (totaling 850 megahertz of spectrum), subject to their use of an equipment-based frequency coordination mechanism that would prevent the unlicensed devices from transmitting on frequencies where such transmissions could cause harmful interference to incumbent services. Lower powered indoor operations would be permitted to operate in two other sub-bands (totaling 350 megahertz of spectrum) unencumbered by frequency coordination.

Discussion of the subject NPRM will use the term "Frequency Coordination" for the more general term "Frequency Management" since historically, in the Part 74 and 101 frequency bands, coordination among users has been an integral part of the frequency management process.



Existing Fixed Co-channel Transmitters and Proposed Allocations per 20 MHz[5]

Note: A single Mobile Special Event Services license such as a Broadcast Auxiliary radio service type Television Pickup license can represent an entire fleet of mobile microwave transmitters.

---

[5] data and graph provided by Comsearch

Existing Licensed 6 GHz Frequency Allocations:

5.925-6.425 GHz: Used by the fixed point to point (Part 101) and fixed satellite (uplink) (Part 25) services.

6.425-6.525 GHz: Broadcast Auxiliary Service and Cable TV Relay mobile applications (Parts 74, 78 and 101).

6.525-6.875 GHz: Used exclusively by fixed point to point service (Part 101).

6.875-7.125 GHz: Primarily serves the Broadcast Auxiliary Service and the Cable Television Relay ("CARS") Service (Parts 74, 78 and 101).

Proposed Unlicensed Frequency Bands

The NPRM proposes the following new unlicensed bands (FCC pages 10 and 29):

U-NII-5:	5.925-6.425 GHz	Access Point EIRP maximum = 36 dBm
U-NII-6:	6.425-6.525 GHz	Access Point EIRP maximum = 30 dBm
U-NII-7:	6.525-6.875 GHz	Access Point EIRP maximum = 36 dBm
U-NII-8:	6.875-7.125 GHz	Access Point EIRP maximum = 30 dBm
All four U-NII bands		Client Device EIRP maximum = 24 dBm

Expected Unlicensed Radio Details

The RKF study[6], funded by Broadcom, Cisco, Facebook, Google, Hewlett Packard Enterprise, Intel, MediaTek, Microsoft and Qualcomm, provided input to this NPRM. It can provide additional information regarding the unlicensed systems:

RKF proposes to introduce 958,062,017 (approximately one billion) unlicensed devices spread across the United States in urban, suburban and rural areas by 2025 (RKF pages 12 and 13).

---

[6] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz,* GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, referenced as "RKF", <https://ecfsapi.fcc.gov/file/101261169015803/6%20GHz%20Ex%20Parte%20(Bureaus).pdf>.

Channel bandwidths range from 20 MHz (10%), 40 MHz (10%), 80 MHz (50%) and 160 MHz (30%) (RKF page 24). The proposed channel plans are not synchronized with any of the existing licensed service plans. Since only one channel is used per system, the modulation is assumed to be Time Domain Duplex (TDD) instead of Frequency Division Duplex (FDD) universally used by the fixed point to point fixed services.

The unlicensed devices will probably have a low duty cycle (in the range of 0.00022% to 0.44% transmission time per RKF study, Table 3-1, page 12), suggesting transmissions will be infrequent.

Automated Frequency Coordination (AFC)

An automated frequency coordination (AFC) function is proposed for all outdoor and some indoor devices (FCC page 7). This system will have a roughly similar frequency management role as the current Citizens Broadband Radio Service (CBRS) Spectrum Access System (SAS) (§96.53) and TV Bands (TWVS) Database Administrator (§15.715). Of course, it is recognized that the AFC, SAS and TWVS will have vastly different functionality.

The AFC must record the actual frequency being used by each standard-power access point (FCC page 32). However, there is no provision for public access of this data. Also, there is no limitation to the number of AFC devices that could be operated in a location. This will complicate interference mitigation from the licensed user perspective.

Access Points

While not stated, the NPRM implies that an Access Point will communicate with one or more Client devices (peer to peer operation is apparently prohibited). The only exception might be a mobile hot spot (FCC page 28). One might infer that the Access Point is fixed and the Client devices may roam.

Standard Power Access Points can operate only on frequencies in the U-NII- 5 and -7 bands determined by an AFC (FCC page 9). Low-Power Access Points can operate on any frequency in the UNII-6 and -8 bands (FCC page 9). Client devices may operate across the entire 6 GHz band (FCC page 9). However, client devices operating in the U-NII-5 and U-NII-7 bands will have to obtain a list of permissible operating frequencies from a standard-power access point (FCC pages 10 and 27).

Since access points may be in a constantly changing location, interference assessment should be made over an area of potential operation (FCC page 21). Whether this is a 2- or 3-dimensional area is not defined.

Commission to Ignore Adjacent Channel Interference

Only co-channel (but not adjacent or next to adjacent channel) interference will be considered (FCC page 16). This is inconsistent with current industry practice[7] for frequency coordination in this band.

Commission to Use ULS Database for Frequency Coordination

The FCC Universal Licensing System (ULS) database will be used for all fixed radio service characteristics (FCC page 14). The database is not completely accurate regarding receiver data. This will undoubtedly cause confusion and misunderstanding among the participants and could cause interference to receivers misrepresented or wrongly located in the database.

[7] TIA Bulletin 10-F, Annex B, and pending ANSI/TIA Standard 10, Chapter 5

Frequency Coordination to Use Propagation Models

The FCC implies propagation models should be used to perform frequency coordination (FCC pages 18 & 19). It should be noted that propagation models estimate typical performance, not actual specific path performance. Frequency coordination requires an accurate conservative estimate of worst case (lowest loss) propagation. No propagation model has been demonstrated to achieve this (For that matter, despite their claims of generality, propagation models have only demonstrated average estimates in limited geographic areas.).

Totally Untried Approach

Lastly, the activities proposed by the NPRM are speculative. They have never been used anywhere in the world and the NPRM proposes to implement its approach without a test. Since we don't know what we don't know, this seems risky. For example, we are not even sure what type of interference will be dominant. Direct Interference is the strong interference experienced today in these bands. Frequency coordination has been effective in managing this (although a practical frequency coordination methodology has yet to be defined for the NPRM's proposals). Indirect Interference is the weak background interference (due to obstructed transmitters illuminating nearby buildings and terrain) common in unlicensed bands in large urban areas today. There is no known way to control this. Comprehensive testing followed by a monitored phase-in of the rules would seem prudent given the potential of low-cost unlicensed systems to disrupt million-dollar licensed paths.

A. Unlicensed Operation in the U-NII-5 and U-NII-7 Bands

The following comments will begin with the paragraph and page number of the FCC NPRM:

(para 23/page 10) U-NII-5 and U-NII-7 and FS Frequency Coordination:

NSMA Comments: In paragraph 44, the Commission proposes to ignore interference except for co-channel. Adjacent channel interference must be considered (see response to para. 44). If the unlicensed service uses a frequency plan not synchronized with the FS frequency plans (as proposed by RKF Figure 3-10 page 24), there will be different exclusion zones for different center frequencies and bandwidths. The NPRM proposes to use propagation models (paras. 48 and 49) to predict the exclusion zones. Frequency coordination is done on the basis of worst-case interference (which is dominated by path free space loss)[8]. Propagation models estimate average path attenuation, not worst case. They are unsuitable for interference prediction of very high reliability microwave paths. Therefore, the industry has not supported the use of propagation models for frequency coordination.

(para 25/page 11) AFC Operation:

NSMA Comments: The FCC ULS has some missing data. AFC operators will have to estimate the missing data and different operators may estimate differently. The AFCs should provide their estimates to other AFC operators so some agreement can be reached. Today ULS updates occur daily which is probably as fast as is practical. If there is more than one AFC operator in an area, there must be some method by which an Fixed Service (FS) or Fixed Satellite Service (FSS) operator can quickly and accurately determine who is assigning frequencies within a geographic area. If excessive interference is believed to occur, with whom

---

[8] ITU-R Recommendation F.1706, Protection Criteria for Point-to-Point Fixed Wireless Systems Sharing the Same Frequency Band with Nomadic Wireless Access Systems in the 4 to 6 GHz Range. Geneva: International Telecommunication Union, Radiocommunication Sector, January 2005, page 1 <https://www.itu.int/rec/R-REC-F.1706/en>

does a fixed user work to confirm harmful interference (based upon an industry definition) and, if confirmed, resolve the issue if necessary (by what means)?

(para 26/page 11): Determining Available Frequencies:

NSMA Comments: The industry should collaborate in determining the method of determining available frequencies.

(para 30/page 11) Unlicensed Device Frequency Availability Reverification:

NSMA Comments: Frequency availability should be verified daily as the FCC database is updated daily. The FCC will need a way to push these updates to the AFCs and receive an acknowledgement. There should be a certain amount of time after this push for the access points to receive their new frequency assignments. An access point that does not receive timely assignments must cease operating.

(para 33/pages 12 & 13) AFC System Operators:

NSMA Comments: Unexpected circumstances will occur causing harmful interference. Someone must be held responsible for resolving these issues. This suggests a limited number of AFC operators using a shared (or synchronized) database.

(para 39/pages 14& 15) Accuracy of ULS Data:

NSMA Comments: The FCC Universal Licensing System (ULS) database will be used for all fixed radio service characteristics. RKF has studied the ULS database extensively. RKF found only 72 % of the ULS receiver data files for the U-NII-5 band were accurate[9]. They

---

[9] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, page 40.

observed there were 91,187 links in the band but only 56,526 entries were accurate[10]. This suggests the overall ULS fixed point to point database is 62% accurate. Each AFC operator will have to estimate missing data. Some method of synchronizing ULS data updates would be helpful. Lack of coordination will result in inconsistent and conflicting coordination results.

(para 40/page 15) ULS Data: NSMA Comments:

The FCC's Universal Licensing System (ULS) database provides details regarding licensed transmitters and receivers. It appears this database is updated daily. Site transmitter data appears reliably documented. Receiver site data less so. Receive site line transmission line losses are not available.

Column heading names, units of measure and overall functions and relationships would be helpful. Vendor of radio and antenna models would also be useful. Using a "pick list" for operator and radio and antenna vendors and models would reduce misspellings and other mistakes. Providing a map of all the database information required to document a path's site and equipment characteristics would be highly helpful.

(para 41/page 15) Temporary Fixed Operation and Conditional Authorization

NSMA Comments: Temporary Fixed operators are secondary to fixed point to point paths, but they must be protected from interference from unlicensed operators. If Temporary Fixed operators want to be protected by the AFC, then they should be required to file a 601 application to notify the FCC of their path parameters and length of operation. Stations that are eligible for conditional authority have already filed with the FCC and provided the relevant path

---

[10] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, pages 40 and 44.

data. These paths should be accounted for in the AFC database since they may already be operational.

(para 42/pages 15 & 16) Protection Criteria:

NSMA Comments: As noted, TIA Bulletin TSB-10-F, the current Part 74 and 101 frequency coordination sources, uses C/I as a protection criterion. When that document was released (1994 - yes, it has been that long ago), analog FM-FDM was the default fixed point to point radio technology. Digital radio is now the fixed point to point technology of choice and T/I is the preferred interference criterion. TIA Committee TR-45 Working Group for Microwave Systems has just drafted a replacement for TIA Bulletin TSB-10-F, ANSI/TIA Standard 10, which is expected to be released this spring. It uses T/I are the default criterion for digital radio systems.

(para 43/page 16) Interference Protection Criteria

NSMA Comments: National and international standards[11] use a single exposure limit of I/N = - 6 as the inter- and intra- system interference criterion (equivalent to a 1 dB receiver threshold degradation). This was also the exposure limit of the RKF study[12]. We concur with the use of the I/N = - 6 criterion.

---

[11] TIA/EIA, *Interference Criteria for Microwave Systems*, Telecommunications Systems Bulletin TSB10-F at B-1, Annex B, Section B-2 (June 1994)
ITU-R Recommendation F.758-6, *System Parameters and Considerations in the Development of Criteria for Sharing or Compatibility between Digital Fixed Wireless Systems in the Fixed Service and Systems in Other Services and Other Sources of Interference*. Geneva: International Telecommunication Union, Radiocommunication Sector (Sept. 2015), at page 9, Table 2.
These sources cite a criterion of I/N = -6, which is equivalent to a 1 dB reduction in fade margin.

[12] RKF study, pages 5, 6, 11, 45, 46, 47, 51, 52, 53, 54 and 58.

(para 44/page 16) Adjacent Channel Protection:

NSMA Comments: We do not agree with ignoring adjacent interference. Attempting to control this interference by limiting out-of-band emissions will not be adequate.

With transmitters and receivers operating with a predefined series of consistently concatenated channels, the inter- and intra-interference interference among similar bandwidth devices can be characterized as co-channel (desired and interfering signals appearing at the receiver with the same center frequency) or adjacent channel (interfering signal appearing at the receiver centered one channel frequency away from the desired signal frequency) or second-adjacent channel (interfering signal appearing at the receiver centered two channel frequencies away from the desired signal frequency). For desired and interfering signal of the same bandwidth, interfering signals more than two channels away from the victim receiver's center frequency can generally be ignored. However, 80% of the unlicensed transmitters[13] are expected to operate with bandwidth of 80 or 160 MHz. For these cases, interference from unlicensed transmitters with even greater frequency separation than second-adjacent must be considered. We will focus on those cases.

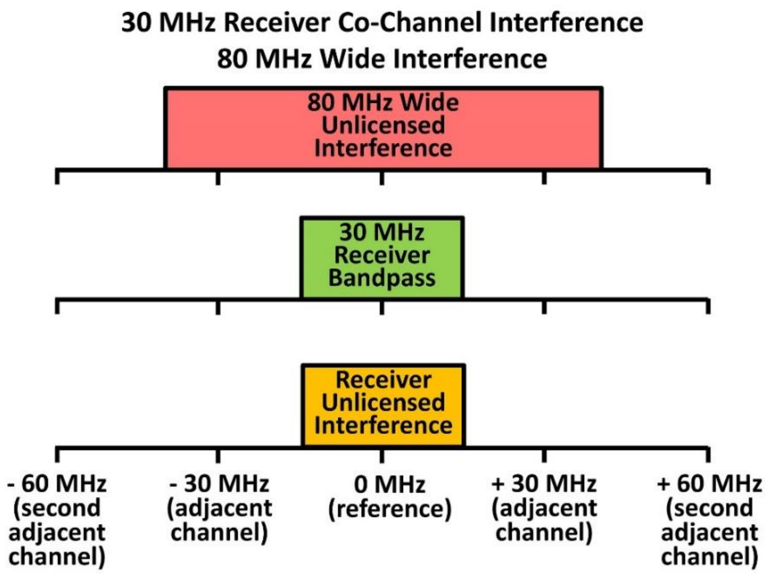
Let's start with a simplified series of examples to demonstrate the basic principles involved. Assume the victim licensed service receivers have a 30 MHz bandwidth using "brick wall" filtering - interference lying outside the 30 MHz channel bandwidth is ignored. Also, let us assume the unlicensed transmitter spectrum is completely contained within its channel bandwidth (no out-of-band emissions) at a constant power level.

---

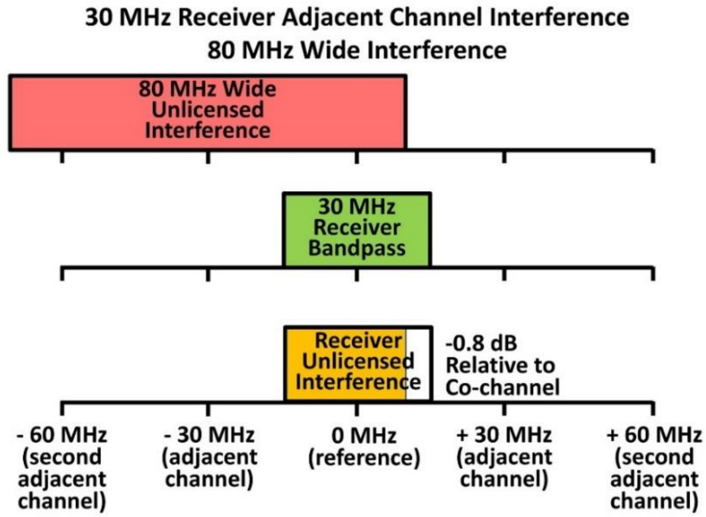
[13] *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band*, January 2018 at 24, Table 3-9, attached to Letter from Paul Margie, Counsel to Apple Inc., et al. to Marlene Dortch, Secretary, FCC (filed Jan. 26, 2018).

Adjacent channel interference, as the term is used by frequency coordinators, is interference centered at a frequency equal to the receiver center frequency plus or minus the receiver channel bandwidth. For a 29.65 MHz (nominal 30 MHz) bandwidth receiver centered at 6034.15 MHz, adjacent channel interference could be centered at 6004.50 MHz or 6063.80 MHz. Second adjacent channel interference would occur for a transmitter centered at 5974.85 or 6093.45 MHz. We will use these conventions

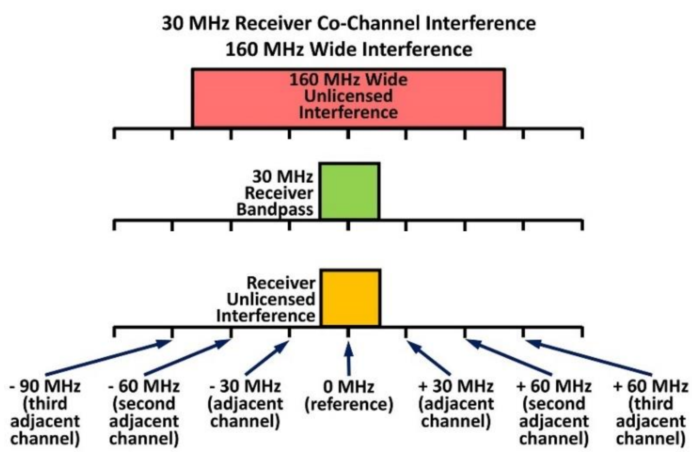
Let's consider the co-channel and adjacent channel interference cases for the 80 and 160 MHz bandwidth unlicensed interference cases:

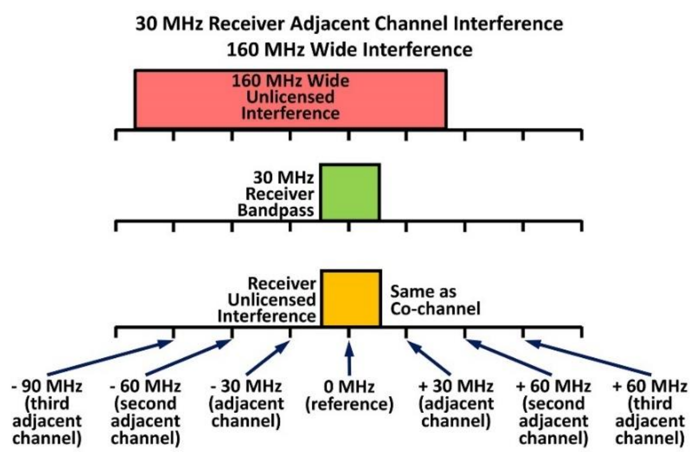


In the above diagram, interference power density is shown vertically and frequency is displayed horizontally. In the co-channel interference case, the interfering signal is centered in the bandpass of the 30 MHz receiver. The receive interference is the portion of the interfering signal that passes through the receiver bandpass filters. Next let's consider the adjacent channel case.

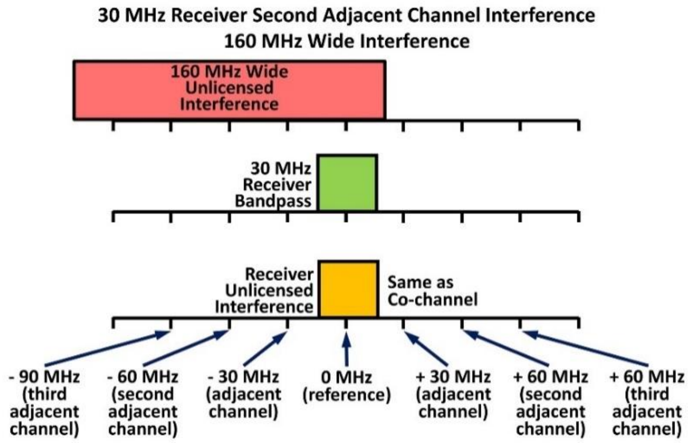


For the 80 MHz wide interference, the receiver interference is approximately 1 dB less than the co-channel case. Next let's consider 160 MHz wide interference:

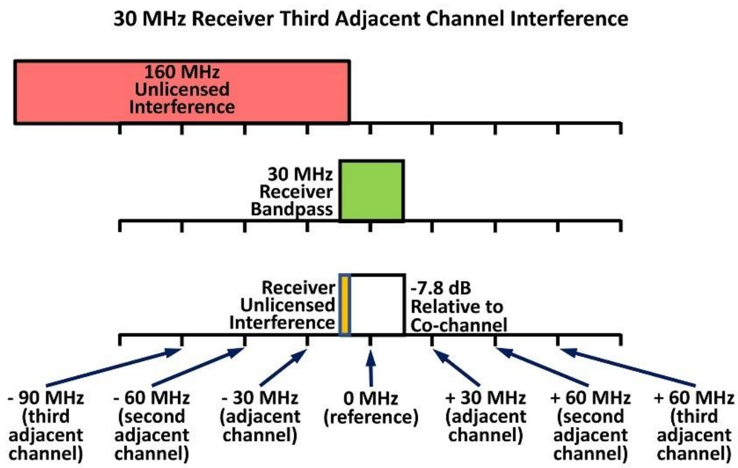




Adjacent channel interference is the same power are co-channel interference.

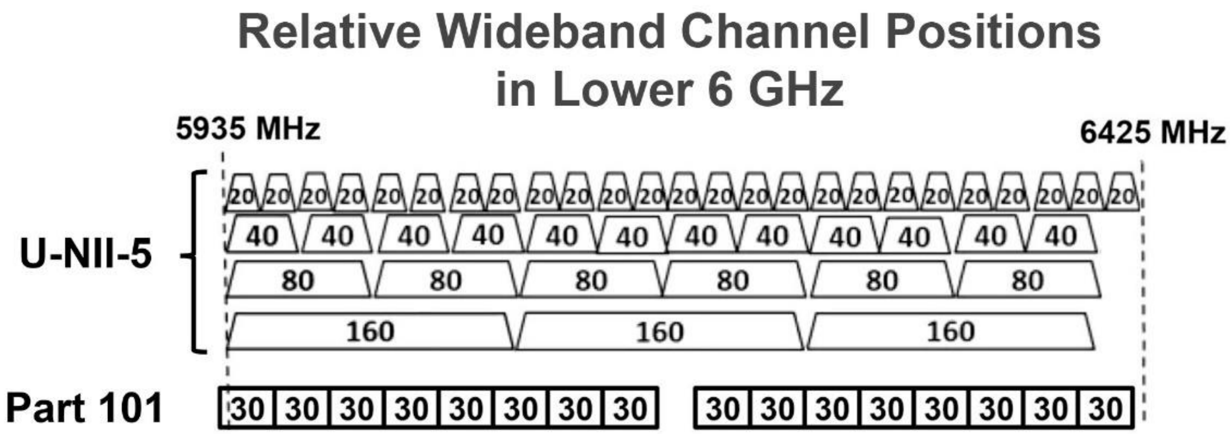


Second adjacent channel interference is just as strong as co-channel interference.



Third adjacent channel interference is about 8 dB less than co-channel interference. Clearly adjacent channel interference must be accounted for. Adjacent channel interference is dominated by direct interference spectrum overlap into the receiver's band pass filters aggregate response.

The above cases are somewhat academic. Real transmitters do have out-of-band emissions and real receivers can receive interference from RF signals outside the receiver's operational channel. Actual interference analysis must take into account those factors. If we assume the unlicensed radio channels will be in accordance with the RKF study[14], the existing licensed service channels will not be aligned with the frequency raster of the unlicensed radio channels.



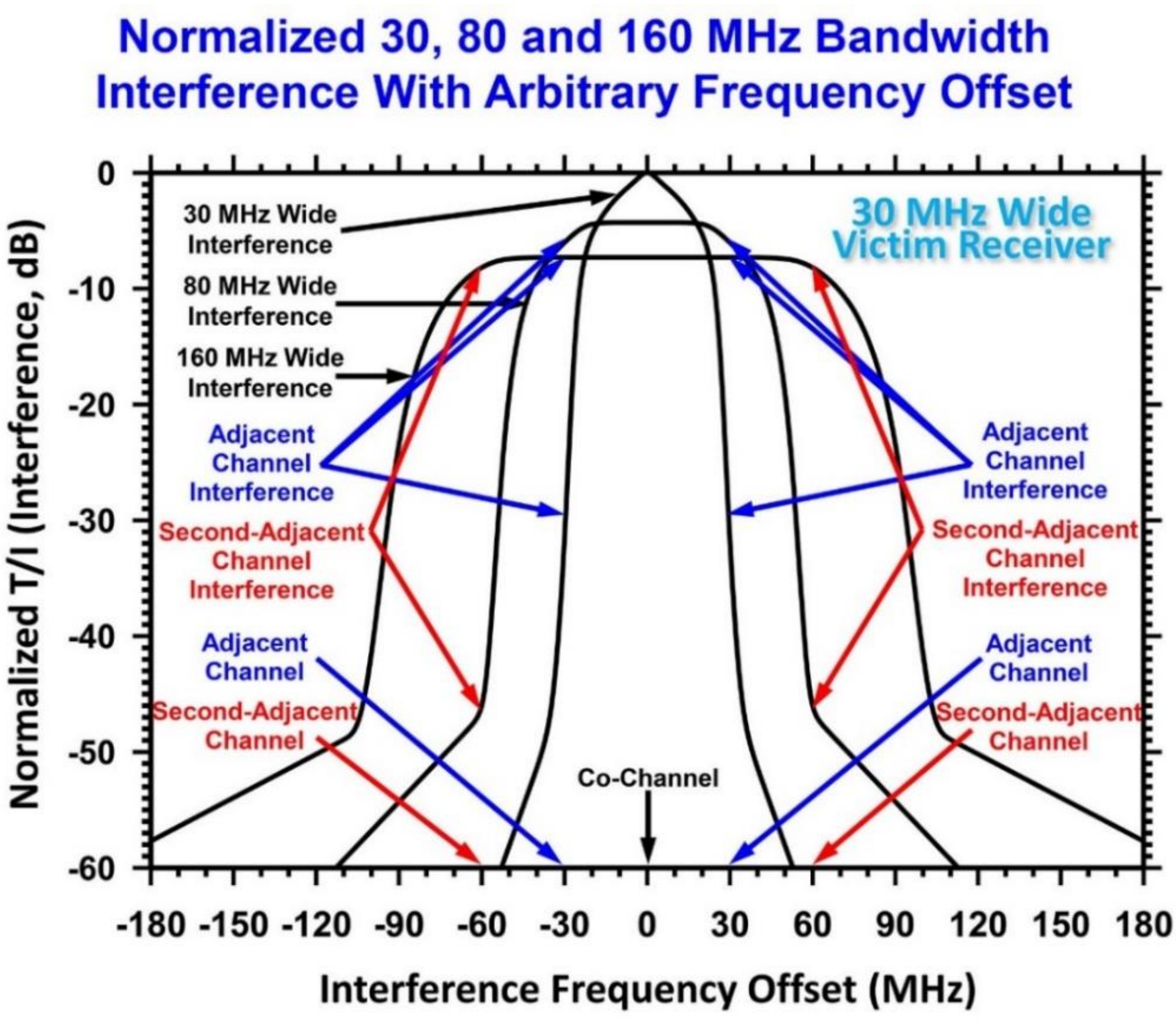
Let us identify channels by their center frequency. For licensed channels, we will only consider those with 30 MHz bandwidth. The 80 MHz channels 5975 MHz and 6375 MHz are essentially co-channel with 30 MHz channels 5974.85 MHz and 6375.14 MHz respectively. The 80 MHz channel 5975 MHz is essentially adjacent channel to 30 MHz channels 5945.2 MHz and 6004.5 MHz and the 80 MHz channel 6375 MHz is essentially adjacent channel to 30 MHz channels 6345.49 MHz and 6404.79 MHz. All the other unlicensed channels are fractions of 30 MHz channel bandwidths away for 30 MHz center frequencies (-81.55 MHz, -51.90 MHz, -48.81 MHz, -40.15 MHz, -38.46 MHz, -29.80 MHz, -29.51 MHz, -22.25 MHz, -20.85 MHz, -19.16 MHz, -17.76 MHz, -11.90 MHz, -10.50 MHz, -8.81 MHz, -0.15 MHz, 0.14 MHz, 8.80

---

[14] *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band*, January 2018 at 24, Figure 3-10, attached to Letter from Paul Margie, Counsel to Apple Inc., et al. to Marlene Dortch, Secretary, FCC (filed Jan. 26, 2018).

MHz, 10.49 MHz, 11.89 MHz, 17.75 MHz, 19.15 MHz, 20.84 MHz, 22.24 MHz, 29.50 MHz, 29.79 MHz, 38.45 MHz, 40.14 MHz, 51.89 MHz).

Since the licensed channels are operating Frequency Division Duplex (FDD) and the unlicensed channels are operating Time Division Duplex (TDD), all unlicensed sites will be "bucking stations" relatively to the licensed sites and are potential interfering sites. They will all require interference analysis but will not fall into the simple cases analyzed above. Using the methodology of Chapter Five of the new draft ANSI/TIA standard 10 due to be published this spring, we may estimate interference for any arbitrary interference frequency offset.



The underlying assumptions of the above graph's derivation is that the victim receiver is a typical licensed 30 MHz receiver and the interference spectrum complies with the emission limitations of FCC rules §101.111 (a) (2) (i). This is more restrictive than the RKF proposal[15] (i.e., this chart predict s less interference than would be the case with the RKF proposal.).

Notice that the adjacent channel and second-adjacent interference due to the 80 and 160 MHz wide interference is significantly greater than the respective interference for 30 MHz wide interference. Currently the Parts 74 and 101 frequency coordination industry requires analysis of 30 MHz adjacent channel interference. Similar treatment of wider bandwidth interference is mandatory.

(para 45/page 16) Multipath Fading:

NSMA Comments: As noted in the NPRM, fixed point to point microwave links are engineered for 25 to 40 dB of fade margin. Fade margin is established using traditional tools (Vigants-Barnett multipath and Crane rain models) to estimate the amount of annual outage that can be tolerated by a given service. For 6 GHz, multipath will be the primary degradation used to determine fade margin. We agree that short distance unlicensed interference, which has the greatest potential for interference to FS links, will not be fading. Longer interference paths will be fading as will the victim path. However, the individual fading events on each path is very short duration. Each fade event will be unsynchronized with the other. For analysis purposes, the interfering path can be considered unfading for path analysis regardless of interfering path length.

[15] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, Figure 5-19 at 53.

(para 46/pages 16 & 17) Multipath Fading:

NSMA Comments: Schiavone of Bell Labs documented[16] that heavy fading occurs between sunset and sunrise plus three hours. While his measurements were made on a path in Georgia, he observed that other researchers had replicated his results in Denmark, England, Canada and Japan. One might be tempted to attempt to reduce fade margin in areas where models suggest fading will be less intense. Given the significant cost associated with large fade margins, we may be sure the operators have already tailored their path's fade margin to the local fading environment. Unused fade margin is unlikely.

(para 47/page 17) Exclusion Zones:

NSMA Comments: We concur in concept with the proposed exclusion zone concept. The exclusion zone should be three dimensional to be realistic. We note that the NPRM example given was for a co-channel interference case. In practice adjacent and semi-adjacent channel interference (as noted in the response to paragraph 44 above) must also be included in the analysis.

(para 48/page 18) Propagation Model:

NSMA Comments: The concept of frequency coordination as implanted in the Part 101 and 74 bands for the last thirty years is to eliminate the worst-case interference case, not the

---

[16] J. A. Schiavone, Meteorological Effect on Diurnal and Seasonal Fading Variations, IEEE international Conference on Communications (ICC 83), Conference Record, Volume 2, pages C2.2.1 - C2.2.4, Boston, June 1983

J. A. Schiavone, Microwave Radio Meteorology: Diurnal Fading Distributions, Radio Science, Vol. 17, Number 5, pages 1301-1312, September-October 1982 average case. We agree with the FWCC's position[17] that "free space path loss model should be used for every link because line-of-sight assumptions will be required unless the AFC incorporates terrain and/or building information that identifies line-of-sight cases with an extremely high degree of reliability". We oppose the use of any currently known propagation model. They only estimate the typical or average propagation case[18]. We discuss this further in the next paragraph. We note that the International Telecommunication Union, Radiocommunication Sector, uses free space propagation rather than a propagation model for evaluating fixed service and unlicensed radio co-location[19].

(para 49/pages 18 & 19) Choice of Propagation Model:

NSMA Comments: As noted above, we do not agree with the use of any currently available propagation model as a frequency coordination tool. All known obstructed path propagation model path attenuation estimates display significant error when compared to any specific path's actual path attenuation[20].

---

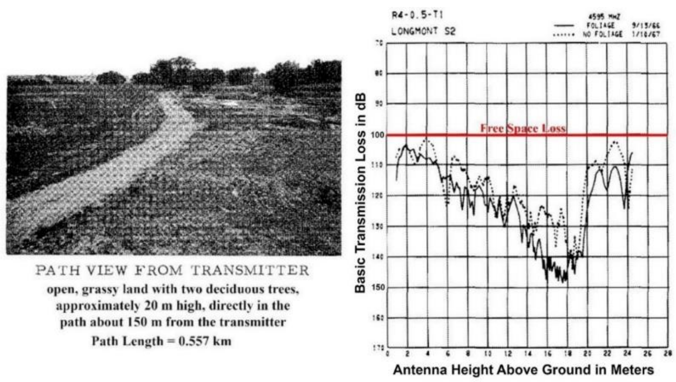
[17] FWCC June 25, 2018 Ex Parte, at 5. While FWCC uses the term "automatic coordination system," the concept appears to be analogous to an AFC. For simplicity, we will use the term "AFC."

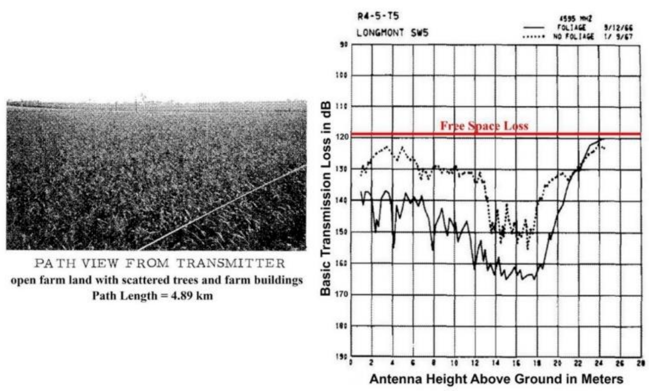
[18] P. McKenna and C. Hammerschmidt, *Propagation Measurement Workshop-Radio Propagation Models*, ITS Boulder, July 28 2016, see entire document, especially pages 12, 34 and 35. <https://www.its.bldrdoc.gov/media/66385/propmeasworkshop3july282016.pdf>

[19] ITU-R Recommendation F.1706, *Protection Criteria for Point-to-Point Fixed Wireless Systems Sharing the Same Frequency Band with Nomadic Wireless Access Systems in the 4 to 6 GHz Range*, International Telecommunication Union, Radiocommunication Sector, 2005, page 1. <http://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1706-0-200501-I!!PDF-E.pdf>

[20] G. Kizer, *Digital Microwave Communication*. Hoboken: Wiley and Sons, 2013, pages 534 and 535, Tables 13.3 and 13.5 and related discussion on those pages.

If we knew all the physical parameters associated with the terrain around a radio path, we - in theory - could immediately have the propagation answer by plugging the factors into Sommerfeld's integrals[21] and cranking out the answer. In reality, that is impossible. Even short, low clearance paths can be deceptively complicated[22].





P. McKenna and C. Hammerschmidt, *Propagation Measurement Workshop-Radio Propagation Models*, ITS Boulder, July 28 2016, see entire document, especially pages 7, 9, 10 and 33-35.. <https://www.its.bldrdoc.gov/media/66385/propmeasworkshop3july282016.pdf>

[21] Arnold Sommerfeld, "Uber die Ausbreitung der Wellen in der Drahtlosen Telegraphie" [The Propagation of Waves in Wireless Telegraphy], *Annalen der Physik*, vol. 28, March 1909, pages 665-736.

[22] P. L. McQuate, J. M.Harman and M. E. McClanahan, *Tabulations of Propagation Data over Irregular Terrain in the 230-TO 9200-MHz Frequency Range Part 4: Receiver Site in Grove of Trees*, NTIA Technical Report OT/TRER 19, July 1971, pages 21 to 26 and 95-100. <https://www.its.bldrdoc.gov/publications/1949.aspx>

The quest to find a practical answer has been ongoing since the 1930's when Ken Norton of the National Bureau of Standards and Harald Friss of Bell Labs began their investigations. Over the period 1968 to 1971 the NTIA's Institute for Telecommunication Sciences (ITS) reported propagation measurements over irregular terrain[23]. Their results demonstrated the complexity of modeling specific path loss attenuation performance.

The first practical model to attempt general estimation of radio wave propagation was the National Bureau of Standards (NBS) Tech Note 101[24]. This evolved into the well-known Irregular Terrain Model (ITM) model[25] of Longley and Rice, probably the best known and most

---

[23] P. L. McQuate, J. M. Harman and A. P. Barsis, *Tabulations of Propagation Data over Irregular Terrain in the 230- to 9200- MHz Frequency Range Part 1: Gunbarrel Hill Receiver Site*, NTIA Technical Report ERL 65-ITS 58, March 1968. <https://www.its.bldrdoc.gov/publications/2041.aspx>

P. L. McQuate, J.M. Harman, M.E. Johnson and A.P. Barsis, *Tabulations of Propagation Data Over Irregular Terrain in the 230-to 9200-MHz Frequency Range Part 2: Fritz Peak Receiver Site*, NTIA Technical Report ERL 65-ITS 58-2, December 1968. <https://www.its.bldrdoc.gov/publications/2042.aspx>

M. E. McClanahan, A.P. Barsis, *Tabulations of Propagation Data Over Irregular Terrain in the 230- to 9200-MHz Frequency Range Part 3: North Table Mountain-Golden*, NTIA Technical Report ERL 65-ITS 58-3, July 1970. <https://www.its.bldrdoc.gov/publications/2043.aspx>

P. L. McQuate, J. M.Harman and M. E. McClanahan, *Tabulations of Propagation Data over Irregular Terrain in the 230-TO 9200-MHz Frequency Range Part 4: Receiver Site in Grove of Trees*, NTIA Technical Report OT/TRER 19, July 1971. <https://www.its.bldrdoc.gov/publications/1949.aspx>

[24] *National Bureau of Standards Technical Note 101, Volumes 1 and 2,* <https://www.its.bldrdoc.gov/publications/2726.aspx> and <https://www.its.bldrdoc.gov/publications/2727.aspx>

[25] A. G. Longley and P. L. Rice, *Prediction of Tropospheric Radio Transmission Loss Over A Computer Method-1968,* ESSA Technical Report 79-ITS 67,

mature general radio propagation tool today. The Commission notes[26] it is "a well-known and widely used prediction tool." It represents the most mature, well studied irregular terrain model in use today. Its limitations are representative of irregular terrain models in general so we shall spend some time describing its performance. We will start with the Institute for Telecommunications Sciences report from ESSA[27].

The ITM model can operate in the area or point to point mode. In the area mode, the average roughness of the terrain Δh is calculated within an area of interest. Propagation among locations is estimated. Here are a couple of examples of results from page 9 of the report with frequencies that are closet to 6 GHz:

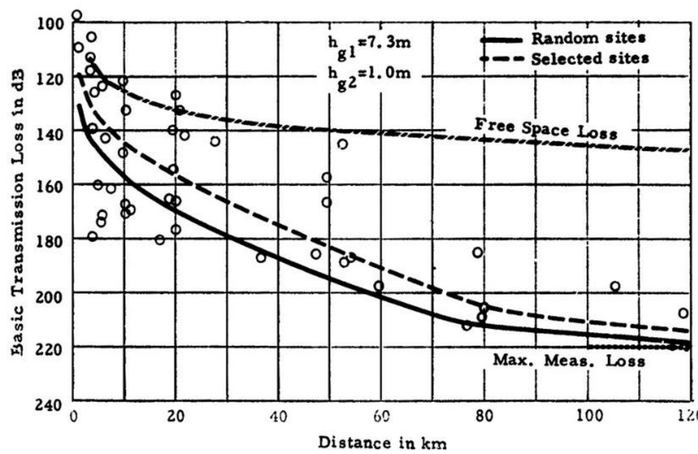


Figure 4. Basic transmission loss, measured and predicted, (top) common receiver site R-1, Δh=90m, f=4595MHz.
h_{g1} = transmitter height h_{g2} = receiver height Δh = area roughness

---

<https://www.its.bldrdoc.gov/publications/download/ERL%2079-ITS%2067.pdf> and updates at <https://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>

[26] Notice of Proposed Rulemaking (NPRM), *Unlicensed Use of the 6 GHz Band*, ER Docket 18-295 (FCC 18-147), paragraph 49, page 18.

[27] A. G. Longley and R. K. Reasoner, *Comparison of Propagation Measurements with Predicted Values in the 20 to 10,000 MHz Range*, ESSA Technical Report ERL 148-ITS 97, 1970, <https://apps.dtic.mil/dtic/tr/fulltext/u2/703579.pdf>

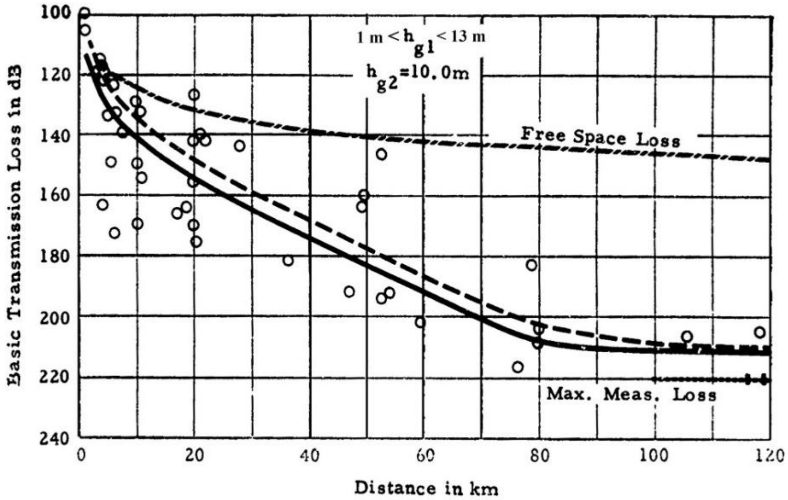


Figure 4. Basic transmission loss, measured and predicted, (bottom) common receiver site R-1, Δh=90m, f=4595MHz.
h_{g1} = transmitter height h_{g2} = receiver height Δh = area roughness

As we would expect from a propagation model, the actual path transmission losses vary significantly above and below the estimates.

ITM can also be operated in the point to point mode. In that case, a conventional path profile (a set of distance and elevation data sets describing the path's terrain) is used to estimate path loss. The following are a couple of examples (pages 58 and 66 of the report) of results using that mode:

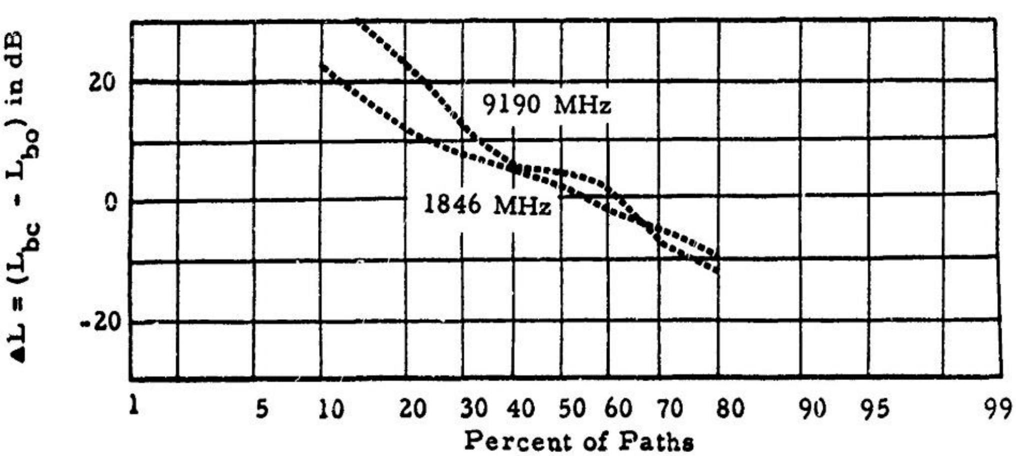


Figure32. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, R-1, h_{g2}=2 m, f=1846 and 9190 MHz.
Lbc = Transmission Loss Predicted Lbo =Transmission Loss Observed
Colorado Sites

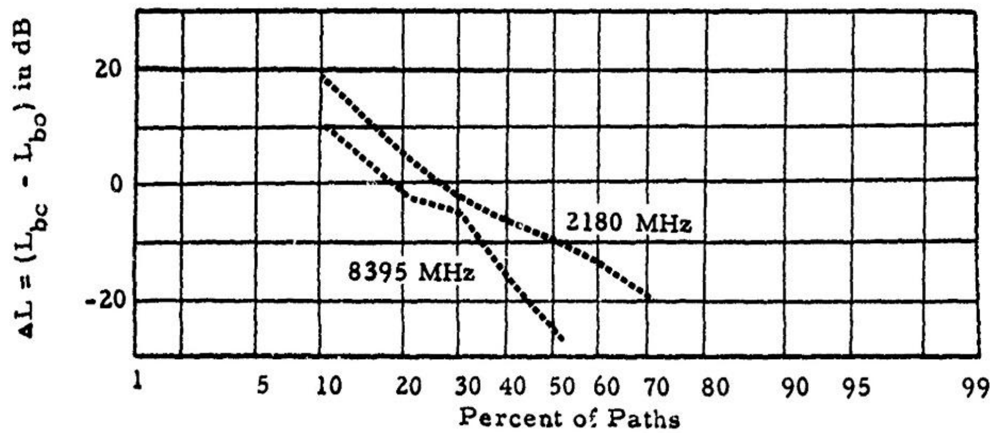


Figure39. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Virginia, f=2180 and 8395 MHz.

Lbc = Transmission Loss Predicted Lbo =Transmission Loss Observed

Virginia Sites

Again, the performance is not precise. The model predicts more than 10 to 20 dB transmission loss than observed for 10% of the paths. The specific path modeling error should not be interpreted as a defect in the model. Its primary purpose was estimating coverage for radio broadcast services, not specific path loss[28]. It performs the coverage function well. It just does not work precisely for specific paths.

A more recent ITS report investigated errors associated with point to point predictions of ITM and the DoD's Terrain Integrated Rough Earth Model (TIREM). The report analyzed 13 different data sets[29] of 41,000 measurements taken at various frequencies in Colorado, Virginia, Washington and Wyoming. The standard deviation of the estimation error for ITM ranged from 9.2 dB to 25.7 dB with an average of 14.0 dB. The standard deviation of the estimation error for

---

[28] Private conversation between George Kizer and Anita Longley in Boulder, Colorado, in 1975.

[29] A. Paul, P. McKenna and F. Najmy, "Evaluation of Two Site-Specific Radio Propagation Models", *Proceedings of the International Symposium on Advanced Radio Technologies*, NTIA Special Publication SP-03-401, March 2003, <https://www.its.bldrdoc.gov/publications/download//2003%20ISART%2003-401%20Paul.pdf>

TIREM ranged from 6.0 dB to 20.8 dB with an average of 12.8 dB. In some cases, the difference between the ITM and TIREM path transmission loss estimate was as much as 20 dB. The authors of the study reported "… the variances of the two models' prediction errors predominantly depend on how well or poorly the path is modeled. Therefore, good terrain data and better information about the particulars of each path are important for reducing models' prediction errors, in addition to improving the quality of the physical approximations used in the models. Additional information regarding vegetation, buildings, urban clutter, ground constants, atmospheric refractivity, etc., seems also to be needed."

After fifty years of research (at least by ITS[30]) on this problem, we still don't have a path model accurate enough for point to point frequency planning. A precise point-to-point path model is impossible in principle, unless it's free space all the way, because anything else can potentially overestimate the attenuation in a particular case.

(para 52/pages 20 & 21) Professional Installation and Height Accuracy:

NSMA Comments: NSMA endorses a "professionally installed" requirement for standard-power access points. The installer certification should be from an entity that is independent from the provider of the access point device and must apply by name to the installer; that is, generic certification by a manufacturer or provider of an access point would not be acceptable. Examples of existing certification bodies that NSMA believes should be acceptable would be any level of certification by the International Association for Radio, Telecommunications and Electronics (iNARTE), any level of certification by the Society of Broadcast Engineers, Inc. (SBE), any level of certification by the Electronics Technicians

---

[30] <https://www.its.bldrdoc.gov/programs/propagation-modeling-website-pmw.aspx>

Association (ETA), any person holding an FCC General Radiotelephone operator's license, or any person holding any class of FCC Amateur radio license. The point is that allowing an access point provider to designate who is a "professional installer" gives them influence over the installer. After all, almost all of the proposed restrictions are to ensure that a Part 15 U-NII access point device does not cause interference to an incumbent licensed station restricts or otherwise reduces the effectiveness of the access point to the end user. An access point provider or an end user has an incentive to cut corners. If the "professional installer" has some form of certification or license in his or her own name and from an entity independent of the service being provided, the installer will be less likely to be influenced by others.

While unlicensed radios have a long history of providing useful service, these is a long history of a few "bad apples" causing harmful unlicensed interference to critical protected services. Therefore NSMA submits that there are compelling reasons to ensure that "professionally installed" actually means something.

B. Unlicensed Operation in the U-NII-6 and U-NII-8 Bands

(para 59/page 23) Unsupervised Operation in U-NII- 6 and U-NII-8:

NSMA Comments: There is no evidence low powered unlicensed indoor transmitters pose no threat of interference to licensed operations. This issue needs to be addressed factually.

C. Other Unlicensed Operation Options

(para 73/page 27) Low Power Indoor Operation in U-NII- 5 and U-NII-7:

NSMA Comments: All U-NII-5 and U-NII-7 operation must be under the control of an AFC.

D. Technical Rules

(para 82/page 30) Out-of-Band Emission Limits

NSMA Comments: Regarding the out-of-band emission limits, we prefer those of FCC rules §101.111 (a) (2) (i) since those currently apply to Part 101 transmitters and our coordination procedures are set up to analyze those. However, we are open to other limits.

Receiver's sensitivity to interference varies with the specific frequency of the interfering RF energy. Most digital transmitters scramble the modulating signal (to eliminate periodic framing bits) to randomize the transmitter's modulated signal. This usually produces a relatively well defined "smooth" transmitter spectrum. If the scrambler is not effective or if clock signals leak into the modulating signal, coherent "frequency spike" energy can appear in the modulated signal. These spurious signals can invalidate our interference estimation methods. It is important they are controlled and not allowed to become significant. Use of wide bandwidth measurements "average out" unwanted coherent energy. We strongly urge the use of a narrow (3.61 or 10 kHz) measurement bandwidth[31] in specifying out-of-band emission limits

(para 83/pages 30 & 31) Transmit Emission Mask:

NSMA Comments: Please note our response above to paragraph 82. We have no objection to the RKF RLAN emission mask[32] as long as emission measurements are made using a 3.61 or 10 kHz measurement bandwidth.

---

[31] The use of 4 kHz measurement bandwidth is no longer needed since there is no longer a need to protect 4 kHz bandwidth audio channels carried on analog FM-FDM radios.

[32] Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, filed January 26, 2018, Figure 5-19 at 53.

(para 90/page 32) Interference Resolution Process:

NSMA Comments: We made comments on paragraph 87 regarding this process. We believe some defined entity should be responsible for resolving interference cases. Otherwise victims will have to canvass all responsible agencies and ask for assistance. Restricting the number of "chefs in the kitchen" should be considered to reduce how many agencies a victim needs to interact with to get resolution. It is proposed that AFC registration databases be shared or synchronized so any AFC could be hired to perform interference mitigation even if they have not registered the unlicensed device.

CONCLUSION

In principle we support the Commission's approach to merge licensed and unlicensed services. If this can be successfully implemented, it will usher in a new, highly efficient, approach to frequency management. As expected, however, the devil is lurking in the details.

Given this new approach is unproven, we should proceed cautiously. A key component of the process will be the AFC function. The authorized agencies must meet the needs of all parties but be limited in number to avoid difficulty in determining the responsible agency for problem resolution.

Another key component is a technical organization with extensive technical oversight and authority. An independent industry organization which is responsive to the needs of all interested parties should be used to develop the myriad of details needed to successfully implement these proposals. Among these would be the development of an appropriate path attenuation model adequate to protect licensed users. The organization's responsibility should extend several years into the implementation phase. This organization should be allowed to develop technical details acceptable to operators and service providers and periodically report progress to the Commission. NSMA is one of a few organizations qualified to participate in this function.

Field trials, monitored by all interested parties, should precede large scale implementation. The field trials should be based upon substantial agreement among all users. Large scale deployment should not begin until the field trials have been successfully completed to the substantial satisfaction of all parties.

A "fall back" plan should be defined before large scale deployment begins. This might require one or more services moving to another frequency band if the plan becomes impractical.

We look forward to working with the Commission in this new world of disparate services frequency management. Indeed, we live in interesting times.

Respectfully submitted,

/s/ David Meyer
David Meyer
Chairman, Working Group 3
NATIONAL SPECTRUM MANAGEMENT ASSOCIATION
P.O. Box 703016
Dallas, TX 75370-3016
703.726.5656

February 15, 2019